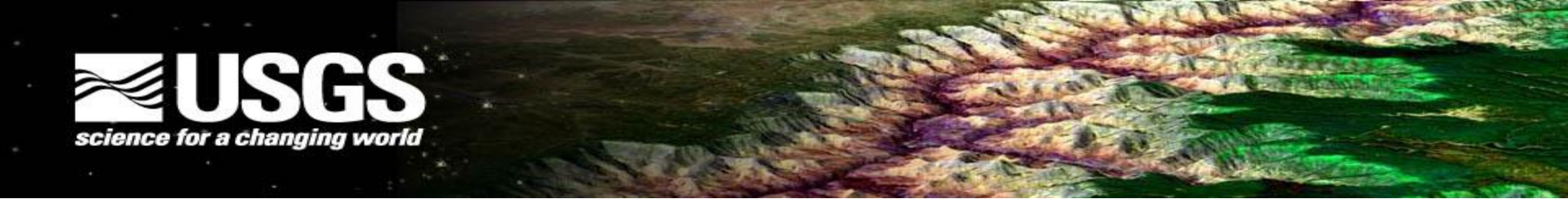

USGS MSS Collection Plans and TIRS SSM Update

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Overview

- **Current state of MSS**
  - Radiometric issues
  - Geometric issues
- **Plan for MSS Collection 1**
- **Landsat 8 TIRS Alternative Operations Status**
- **Summary**

MSS Data in Archive

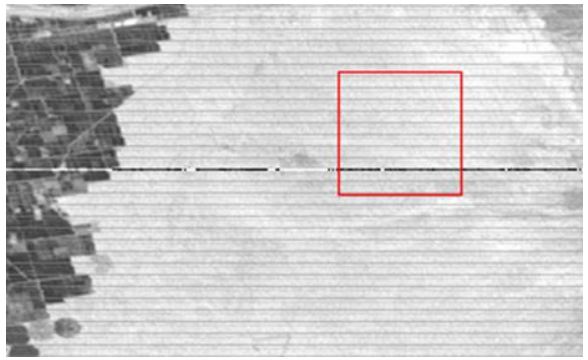
- **Several flavors of MSS data at EROS (**1,306,564 total scenes**)**

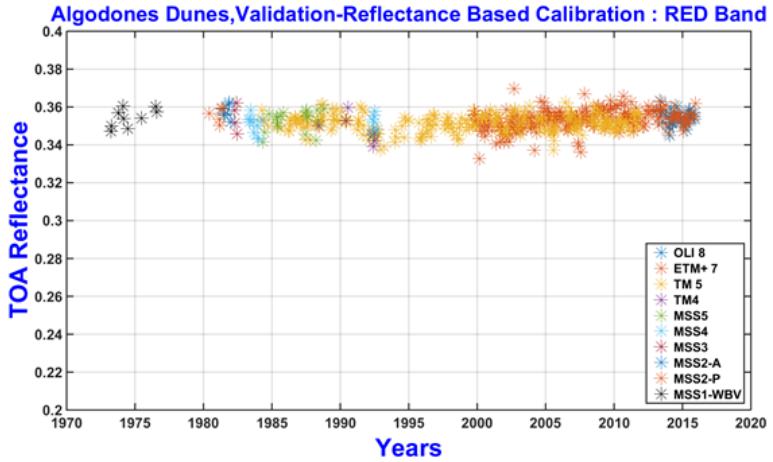
Data Type	Number of Scenes	%L1G	%L1G_FB	%L1T_<30m	%L1T_>30m
MSS-R	707735	6.5%	44.1%	26.1%	23.3%
MSS-X	34076	29.6%	19.3%	27.7%	23.4%
MSS-X (WBV)	264640	32.9%	51.5%	6.8%	8.8%
MSS-X (orphan)	39023	30.6%	47.7%	9.7%	12.1%
MSS-A	243353	3.4%	52.0%	23.5%	21.0%
MSS-P	17737	12.3%	55.6%	13.6%	18.5%

- **MSS archive has increased under Landsat Global Archive Consolidation (LGAC) effort**
  - This has increased the complexity and challenges of processing
  - As more MSS data delivered, further complications may arise

MSS Radiometric Issues

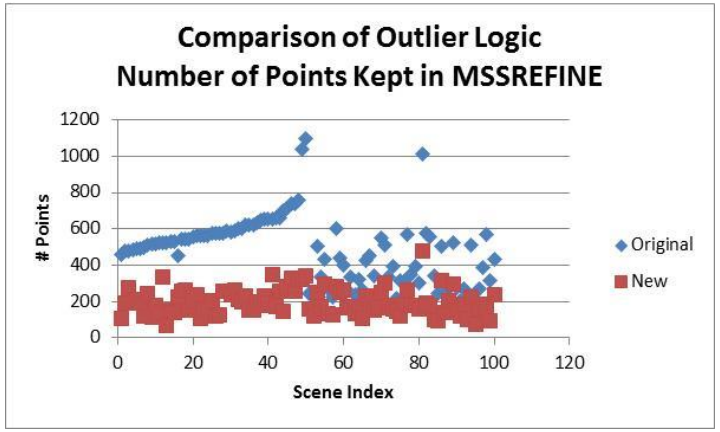
- **Striping issues**
  - Update CPF to fix MSS 3 band 4 striping
  - Investigate additional striping issues
- **Reflectance and radiance based calibration based on MSS-R data tied to L5 TM**
  - SDSU MSS-P reflectance based calibration
  - Develop lifetime model from MSS-R, transfer to all other formats (P, X, A)
- **Saturated L1T data where L0 data not**
  - Adjust Lmin/Lmax
- **Gain trend model across all formats**
  - Verify and update as required

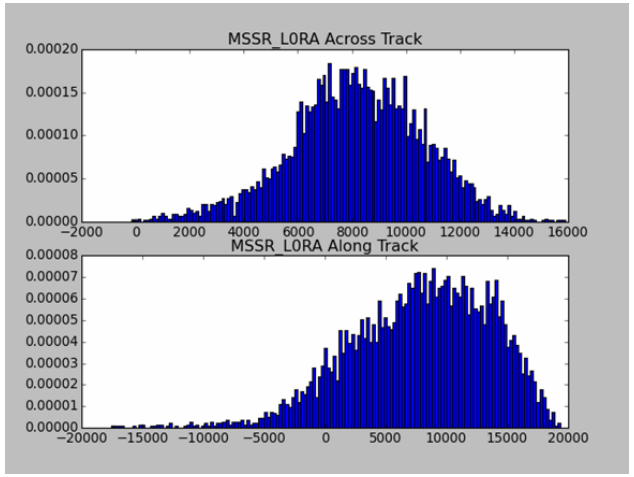




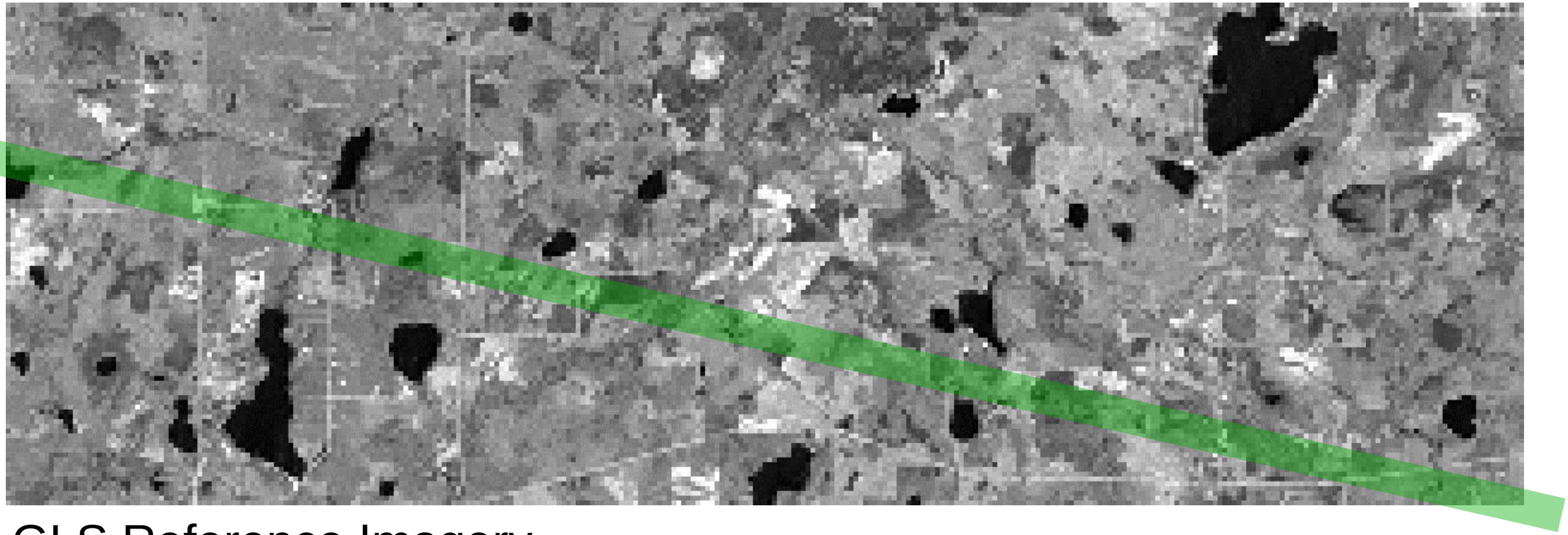
MSS Geometric Issues

- **Update outlier logic to improve L1T performance**
  - Initially thought to improve significant portion of archive
  - Expectations lower after investigating further
- **Attitude bias**
  - MSS-R and orphan lack attitude and ephemeris information (estimated with two-line-elements and perturbation model)
  - Bulk adjustment may produce more L1Ts
- **Missing scans in some MSS-R data (next slide)**
  - Re-ingest all raw data
- **MSS-P band 7 misalignment**
- **Not planned for Collection 1**
  - Temporal GCPs
  - Improve TLEs for improved satellite position
    - May allow more scenes to get to L1T



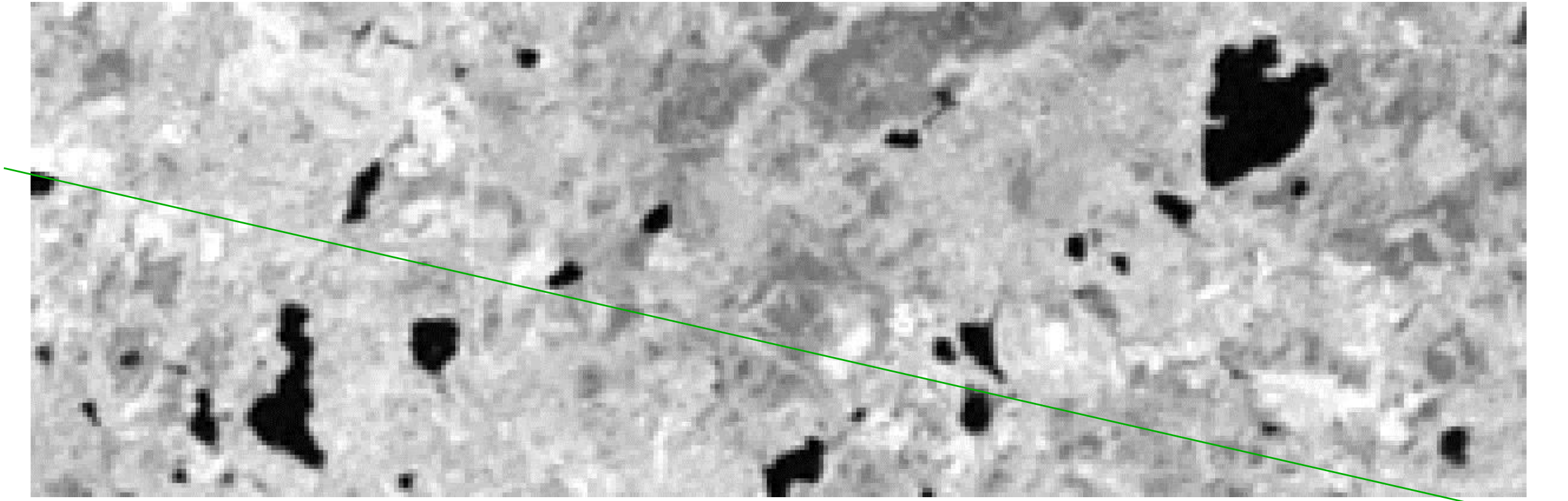


Example of Missing MSS-R Scan



GLS Reference Imagery

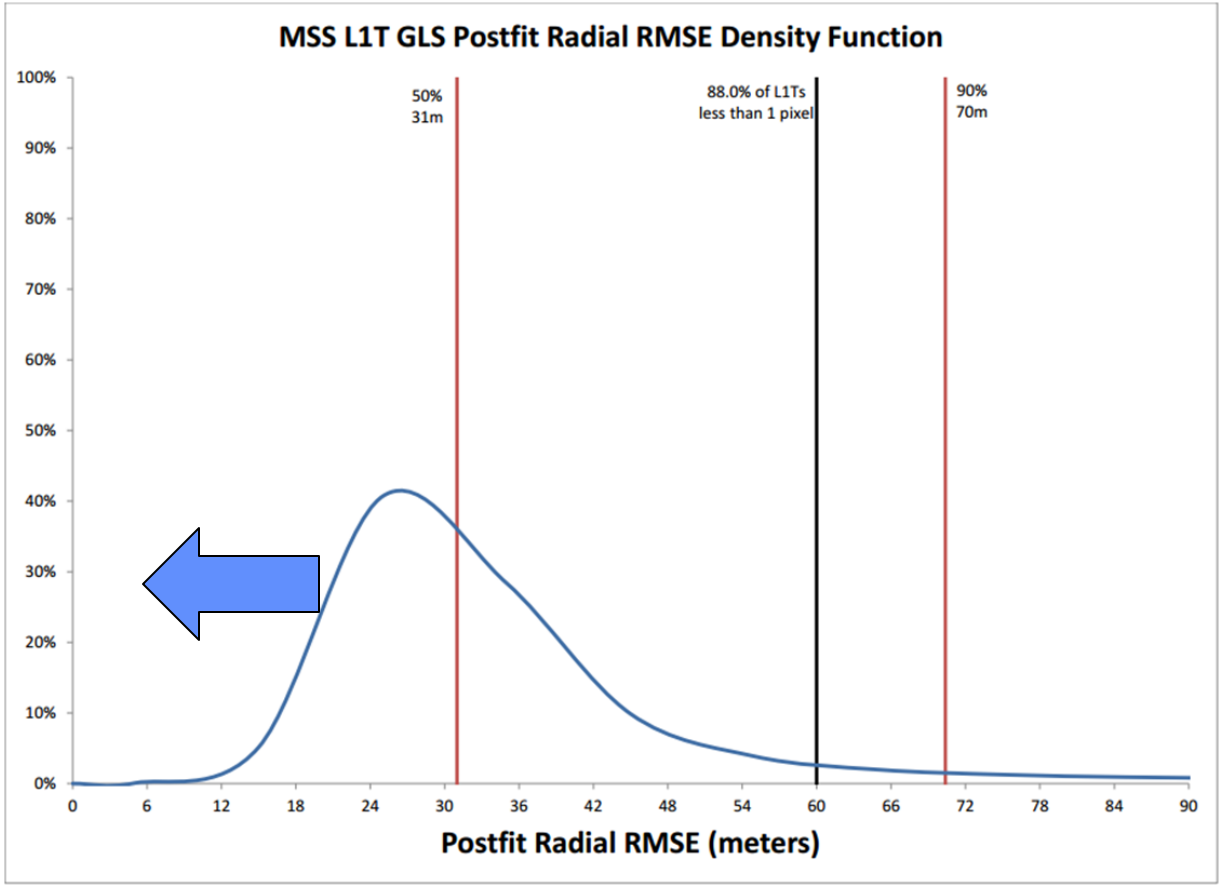
Example of Missing MSS-R Scan



MSS-R Missing Scan

MSS Archive Geometric Accuracy

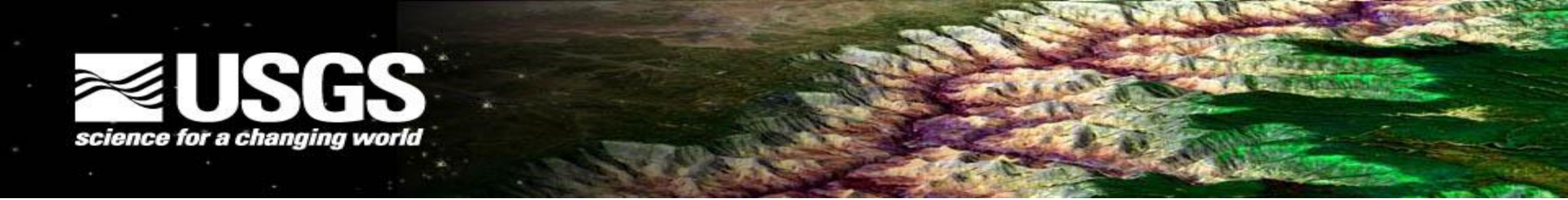
- **Most L1T products from MSS-R**
- **41% of MSS products are L1T**
  - 530,000 products
  - Half within 30m
  - 88% within 60m (one pixel)
- **L1Ts and accuracy expected to improve with changes**



MSS Collection Plan

- **Update calibration coefficients to fix MSS 3 band 4 striping – complete**
- **Fill missing scans in Level 0 – complete**
- **Finalize SDSU reflectance calibration – Summer 2016**
- **Investigations – Fall 2016**
  - Additional striping
  - Gain trend model
  - Band 7 misalignment
  - Attitude bias
- **Identify software changes, with algorithm updates – Winter 2016**
  - Outlier logic and others as determined in investigations
- **Determine Collection 1 MSS definition – Winter 2016**
- **Update CPF – Spring 2017**
  - Lmin/Lmax to eliminate unnecessary saturation
  - Gain trend model as needed
- **Begin collection processing – Summer 2017**
  - After TM, ETM+ and OLI/TIRS Collection 1 processing complete

- **Don't expect all issues to be resolved**
- **Document all issues investigated (addressed or not)**



TIRS Alternative Operations Status

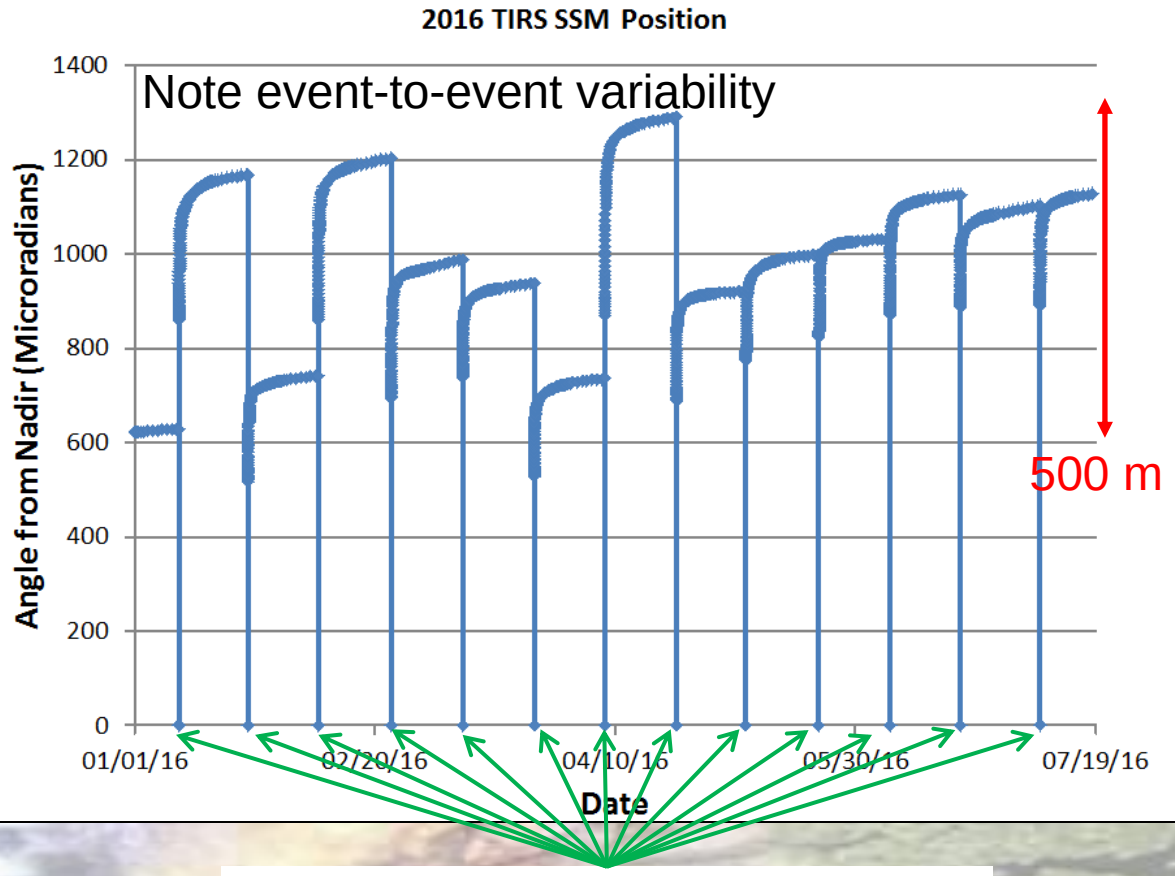
U.S. Department of the Interior
U.S. Geological Survey

TIRS Scene Select Mechanism Status

- **The TIRS SSM is now being operated in a manner designed to extend its operational life**
  - Open loop (mode 0) control is used for most Earth imaging
  - Closed loop (mode 4) control is only used for periodic radiometric calibration operations
- **Calibration operations are nominally conducted every 14 days, linked to the lunar calibration cycle**
  - The SSM position encoder is turned off (to extend its life) once the calibration is completed and the SSM has been returned to mode 0 operation
- **Real-time SSM position telemetry is not available once the encoder is turned off**
  - SSM position is estimated off-line and provided to ground processing as a table of estimated SSM angles vs. time

TIRS SSM Position Variation

- **Each calibration event resets the SSM position model**
  - Initial rapid motion is measured by leaving the encoder on for approximately 1 orbit following mode 0 transition
- **Long term motion is monitored using image measurements from geometric calibration scenes**
  - A model of SSM position is fitted to the encoder and scene data



Assessing Real-Time Data Accuracy

- **SSM calibration scenes provide measure of SSM model prediction accuracy**
  - To estimate the accuracy of the predicted SSM model values used to perform real-time processing, we looked at the pre-fit residuals from the SSM calibration scenes
  - Of particular interest is the accuracy in the first few days following a mode switch when the SSM behavior is changing the most rapidly
- **Critical thresholds**
  - TIRS-OLI registration cannot meet specifications if the prediction error is > 28.4 microradians
  - Nominal performance is expected if the error is < 10 μrad
    - This is not as accurate as the encoder, BUT the image-based calibration also absorbs slowly varying roll-axis TIRS-to-OLI alignment error

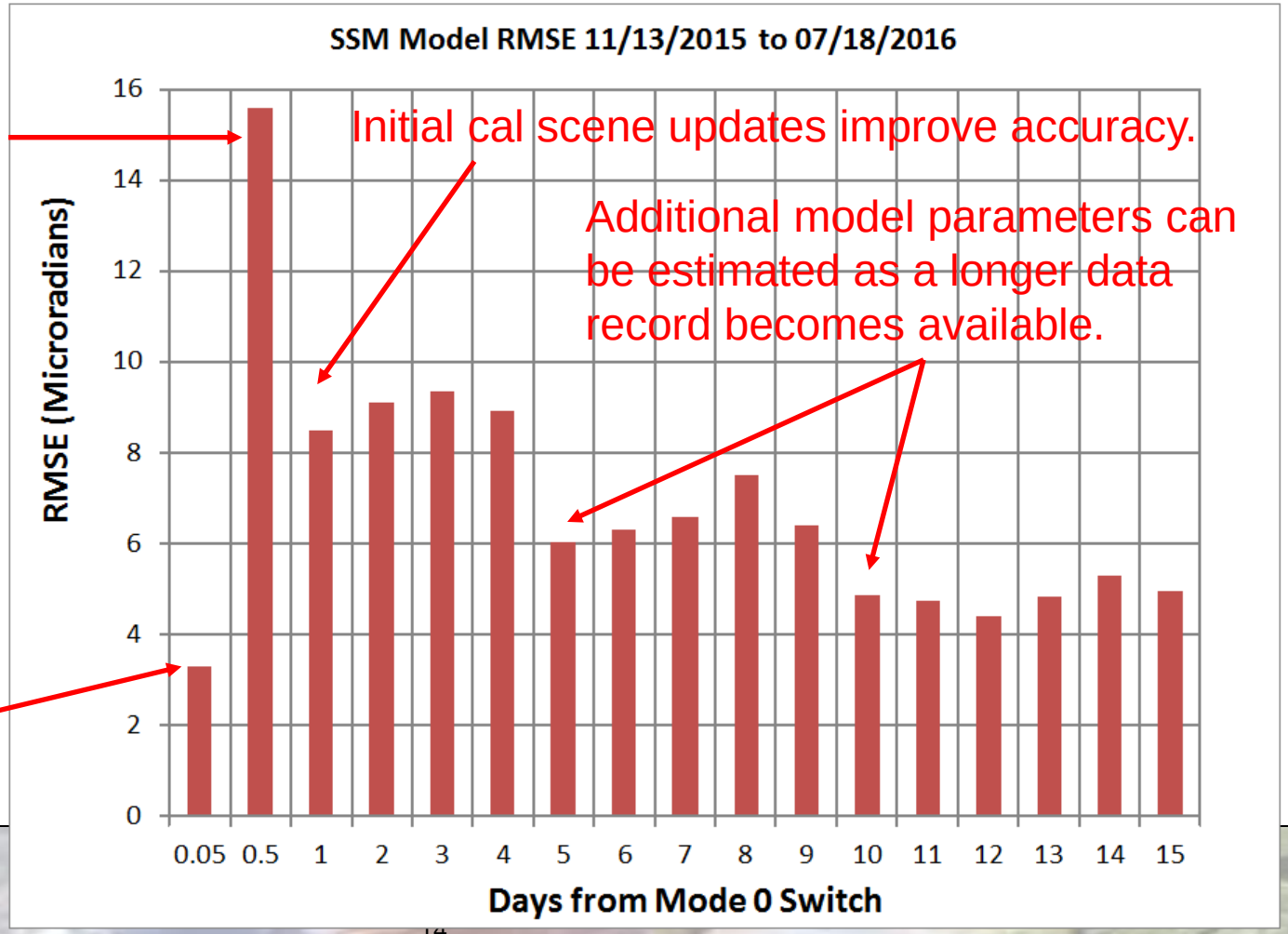
SSM Model Prediction Accuracy

- **Computed RMSE statistics as a function of time since mode switch for all events since November 2015**

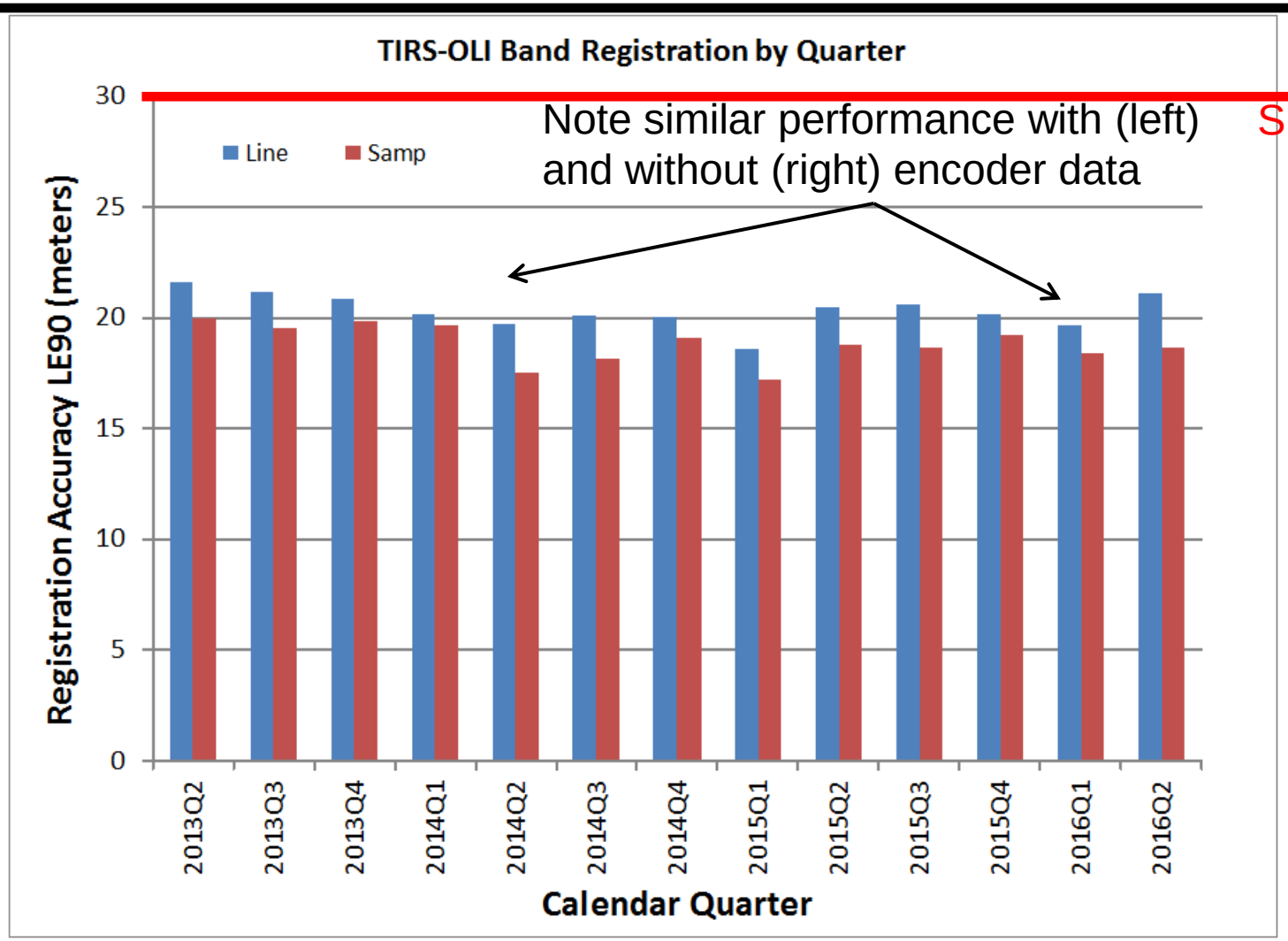
First few orbits without encoder data are the most problematic

Note: Results reflect performance when telemetry and calibration scene data are available when and where expected.

Encoder is still on.



TIRS-OLI Registration After Reprocessing



Summary

- **MSS collections**
  - Investigations underway, completion end of calendar year
  - Calibration coefficients and software updates planned for early 2017
  - Collection 1 processing to begin next Summer
- **TIRS Alternative Operations**
  - About 7 months of experience
  - Initial geometric accuracy degraded
  - Final geometric accuracy similar to accuracy prior to operations change
  - Alternative operations proceeding well
    - Although additional effort required to maintain TIRS geometric acciray